SMART SOUNDING SYSTEM FOR AUTONOMOUS EVALUATION OF CONCRETE STRUCTURES

Dr. Anil K. Agrawal, Deepak Kumar

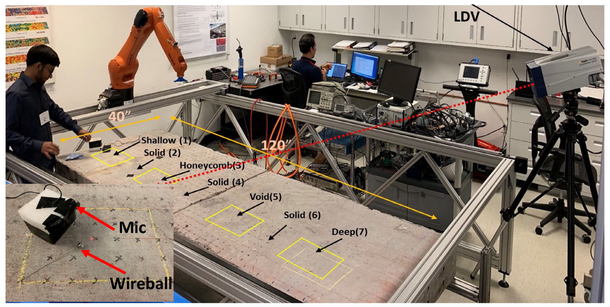
INTRODUCTION

Impact sounding has been used successfully to detect defects in concrete structures. Recent research has shown that the sounding, such as chirp signal, can be generated by electronic speakers, and can be designed with controlled frequency characteristics to excite defects in concrete decks. The bottom of a deck cannot be conventionally sounded, and precise location of the damaged area is a challenge. The focus of this research is on development of a "Smart Sounding System" that can be used to inspect the underdeck and pier surfaces effectively and autonomously.

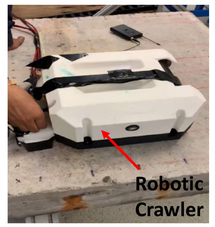
METHODS

Different methods such as **Wireball hammer (mechanical)** and **Sounding tool (Electronic**) have been used to excite the concrete structure. The sounding tool consists of a speaker in a tube to shoot focused sound to the surface. A mems microphone, shielded by foam to reduce environment noise, has been used to collect the vibration response from the surface.

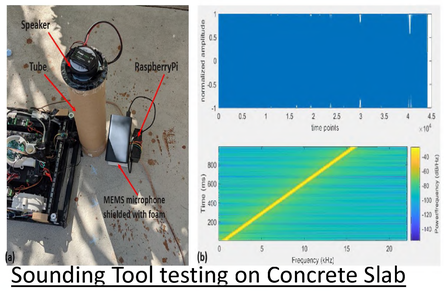
The signals obtained from the microphone contains the surrounding noise. **EMD (Empirical mode decomposition)** has been used to filter the noise. The filtered noise has been used to obtain the frequency spectrum for the analysis using **PSD (Power Spectral Density)** and **HMS (Hilbert Marginal Spectrum).**



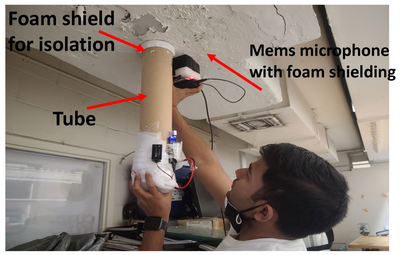
Wireball Hammer testing with LDV on Concrete Slab (FHWA)



Crawler Suction with microphone



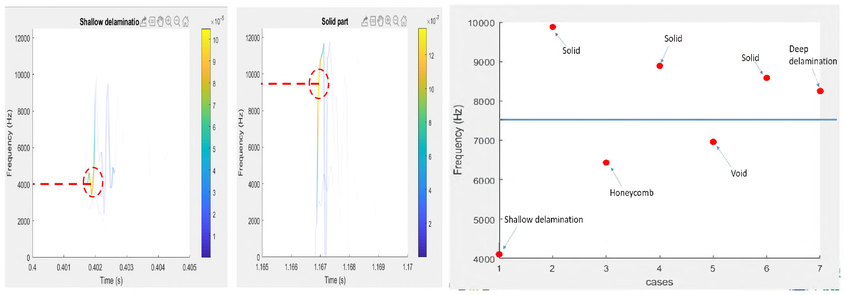
Sounding Tool testing on Concrete Slab (Prof. Xiao's home, tube not isolated)



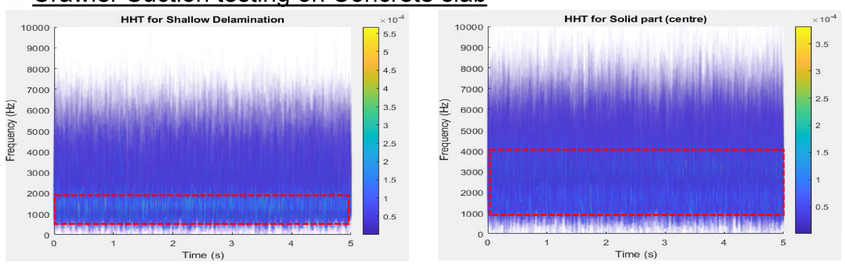
Sounding tool testing at CCNY Basement (Isolated tube)

RESULTS

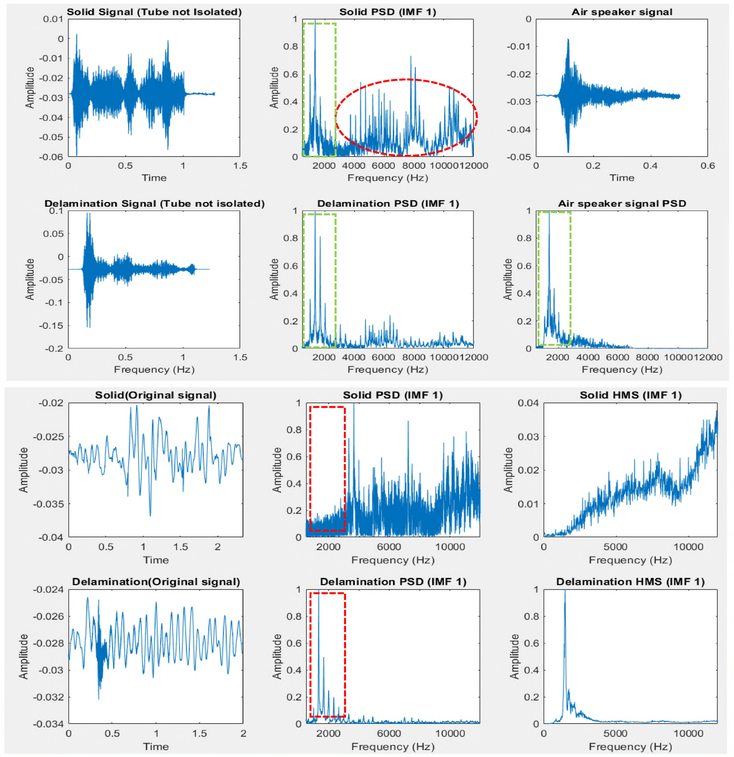
- Wireball Hammer testing on Concrete Slab



- Crawler Suction testing on Concrete slab



- Sounding Tool testing on Concrete (Prof. Xiao's lab & CCNY basement)



CONCLUSIONS

- Mechanical sounding, using Wireball hammer to excite the concrete structure is able to differentiate the different types of defect regions from the solid region.
- The aerodynamic noises (suction) from the Robotic crawler have been found to be able to excite the surface of the concrete slab and detect the defect region. The solid region shows vibration energy for higher frequency band (2-4.5 kHz) whereas the defect region shows vibration energy density for lower frequency band (1-2kHz).
- Electronic sounding, such as chirp sounding, has also been shown to be able to detect damage in concrete structures.
- Solid region shows more vibration energy in the higher frequency region whereas defect region shows vibration in lower frequency band (1-3kHz) which is consistent with the past studies.
- Isolating the tube improves the response signal, reducing the direct signal coming from the speaker and allowing the microphone to receive the vibration from the concrete surface, and thus providing robust method of defect detection.
- Further development is under progress to make this tool integrated with GPS and vision-mapping technologies for practical inspection use.

REFERENCE

Akamatsu, R., Sugimoto, T., Utagawa, N., and Katakura, K. (2013). "Proposal of non-contact inspection method for concrete structures using high-power directional sound source and scanning laser doppler vibrometer." Japanese Journal of Applied Physics, 52(7S), 07HC12.

ACKNOWLEDGEMENTS

Financial support for INSPIRE UTC projects is provided by the U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology (USDOT/OST-R) under Grant No. 69A3551747126 through INSPIRE University Transportation Center (http://inspire-utc.mst.edu) at Missouri University of Science and Technology. The views, opinions, findings and conclusions reflected in this publication are solely those of the authors and do not represent the official policy or position of the USDOT/OST-R, or any State or other entity.

The authors also sincerely acknowledge the support of Dr. Jizhong Xiao at CCNY, Mr. Frank Jalinoos at FHWA in accessing the concrete decks for impact sounding experiment..